BIOSCape - Mapping of phytoplankton functional types (PFTs) from space in support of coastal resource management and decision support activities

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Background

Background – Chl *a* (mg m^{-3})
Cyan line – surface currents

The current u/v : zonal/meridional velocity in m/s
The current is in the first month of each season

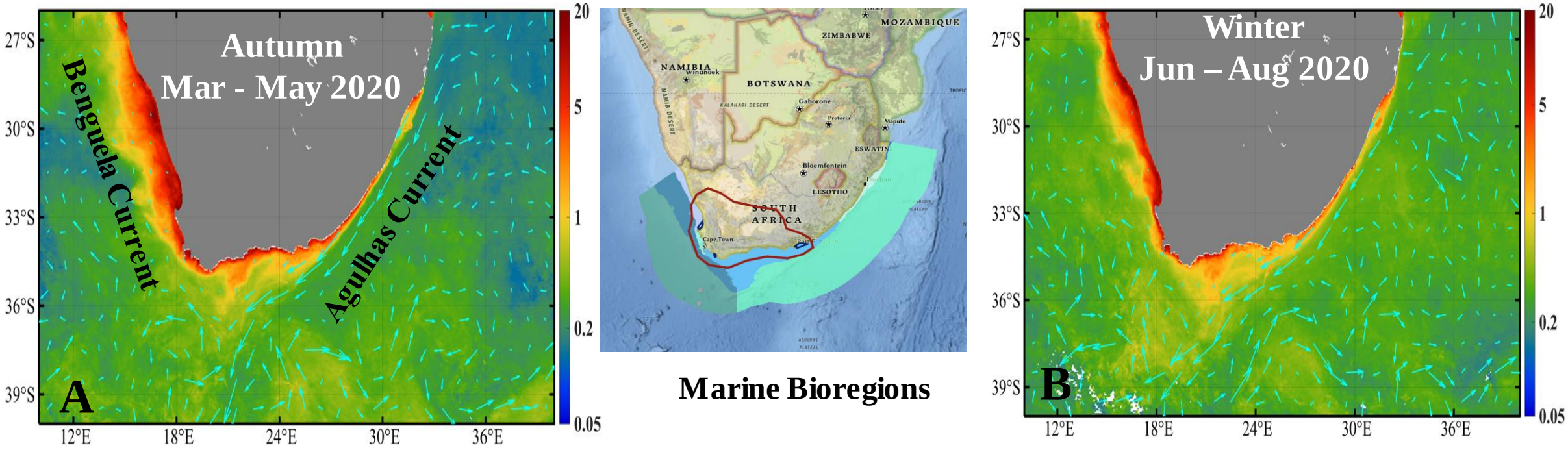
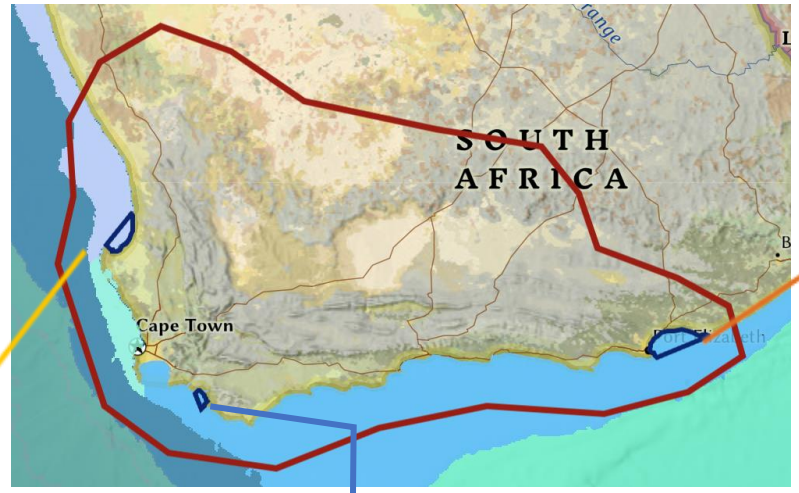


Figure. Seasonally averaged maps of CHL during (A) Autumn and (B) Winter superimposed with OSCAR sea surface currents. Note the flow of the two currents and the contrasting patterns of CHL in the west (intense phytoplankton blooms in Autumn and Winter), moderate CHL in south, stronger in winter (our field season), and low CHL in east for both seasons. The west coast bays are phytoplankton biomass rich almost throughout the year because of coastal upwelling favorable currents and winds.

Research Area

St Helena Bay

www.nmbt.co.za (Pitcher et al, 2019)

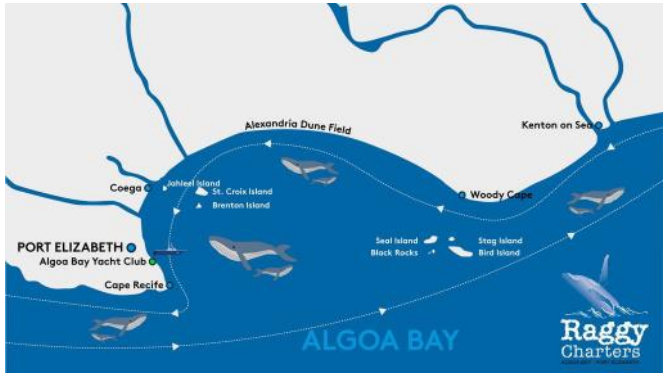


Walker Bay

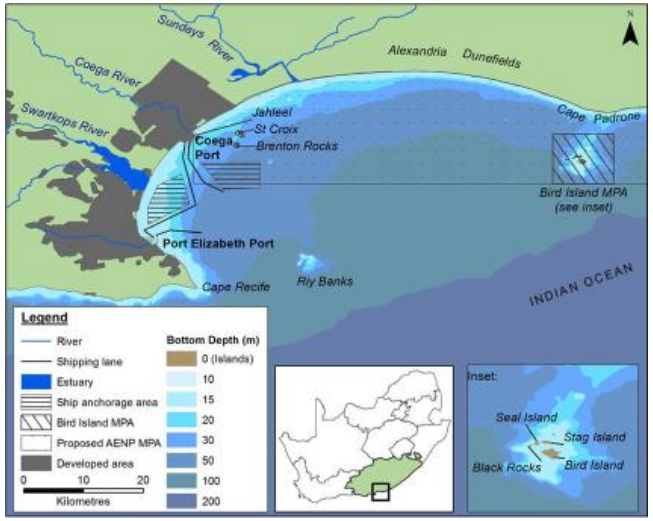
www.saintcooks.com

showme.co.za

Algoa Bay



www.raggycharters.co.za



(Dorrington et al, 2018)

Goal

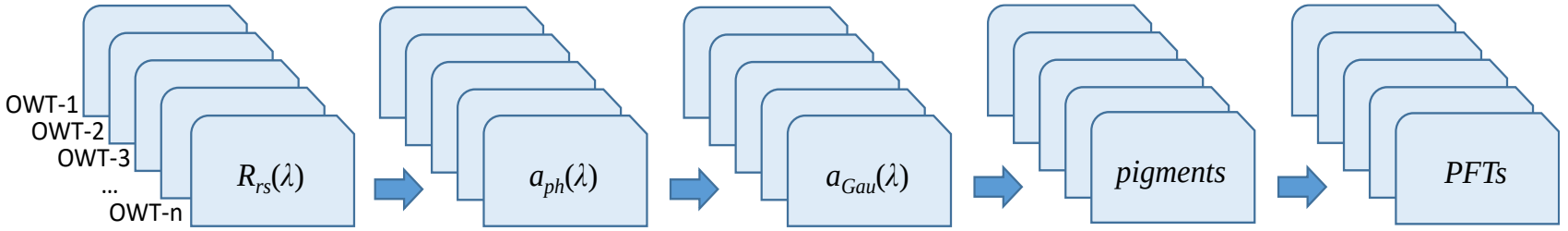
Develop a hyperspectral method for retrieving **phytoplankton functional types (PFT)** within these three bays.

Data Collection

Type	Property and/or description	Methods or instruments	Sampling mode
AOPs	R_{rs} : remote sensing reflectance	SVC Hri (Spectra Vista Corp)	On station at surface
	Ed(z) and Lu(z) : vertical profiles of irradiance and radiance	HyperPro II (Satlantic)	On station depth profile
IOPs	a : total absorption coefficient	ac-s (WET Labs)	Depth Profile/Underway
	c : total beam attenuation coefficient; b_p (=c-a -b_w): particle scattering	ac-s (WET Labs)	Depth Profile/Underway
	b_{bp} : particle backscattering coefficient	BB9 (WET Labs)	Depth Profile/Underway
	a_p , a_{ph} : of particles and phytoplankton,	Filter-pad & spectrophotometer (Shimadzu)	Discrete depth
	a_g : CDOM absorption coefficient	Spectrophotometer (Aqualog)	Discrete depth
Bio-optical	PFTs and PSCs	PFT-Imaging Microscopy (Nikon), FlowCAM (Fluid Imaging), PFT - Algal Online Analyzer (BBE), ALFA (Wetlabs), e-DNA (qPCR, Biomeme "Franklin")	Discrete depth/Underway
	Concentration of CHL and other pigments	Fluorometry (Turner Designs), HPLC (NASA), ALFA (Wetlabs),	Discrete depth/Underway/Profile
	PSCs and/or PSD	FlowCAM	Discrete depth/Underway
	CDOM concentrations and slopes	Spectrophotometer	Discrete depth
Bydrography Currents, Nutrient, Carbonate Chemistry	Temperature, Salinity, Oxygen, pH profiles, Curents, pCO_2, inorganic nutrients,	CTD, pH and DO Sensors (profiles, ADCP, Nutrients (discrete), pCO2 and pH underway,	Discrete depth/Underway/Flowthrough

Method

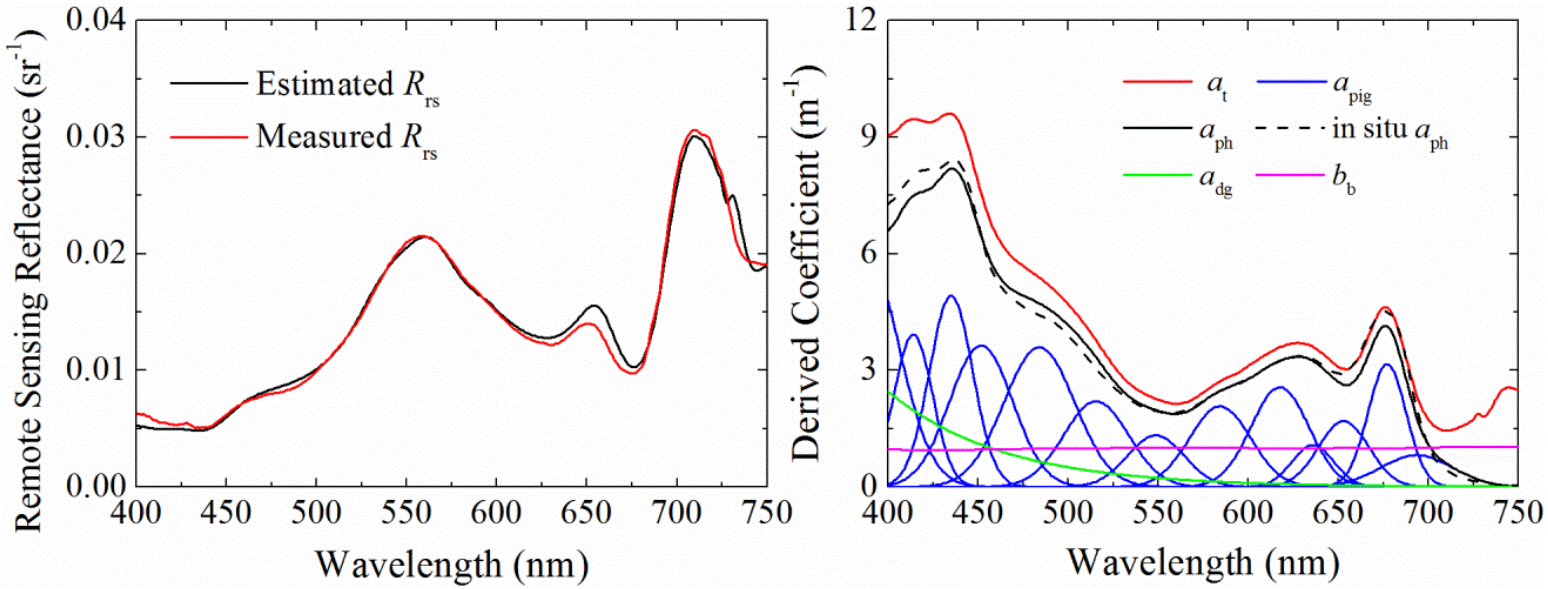
Multi-pigment inversion model (MuPI)



$$R_{rs}(\lambda) = f\left(\frac{b_b}{a_t + b_b}\right) = f\left(\frac{b_{bw} + 0.01\left(c_s - a_{ph}(\lambda)\right)}{\sum_{i=1}^{n} a_{gaus}(\lambda_i)\exp\left[-0.5\left(\frac{\lambda - \lambda_i}{\sigma_i}\right)^2\right] + a_{dg}(\lambda_0)\exp\left(-S(\lambda - \lambda_0)\right) + a_w + b_{bw} + 0.01\left(c_s - a_{ph}(\lambda)\right)}\right)$$

Where

- a_{gaus} and s(λ) are the peak magnitude and width of the i^{th} Gaussian Curve
- $a_{dg}(\lambda)$ is absorption coefficient of detritus and colored dissolved organic matter
- a_w (λ) is the absorption coefficient of seawater
- c_s is the beam attenuation coefficient
-



(Wang et al. 2016; Wang, Lee & Mouw, 2017)

Case 1: Application to coastal area

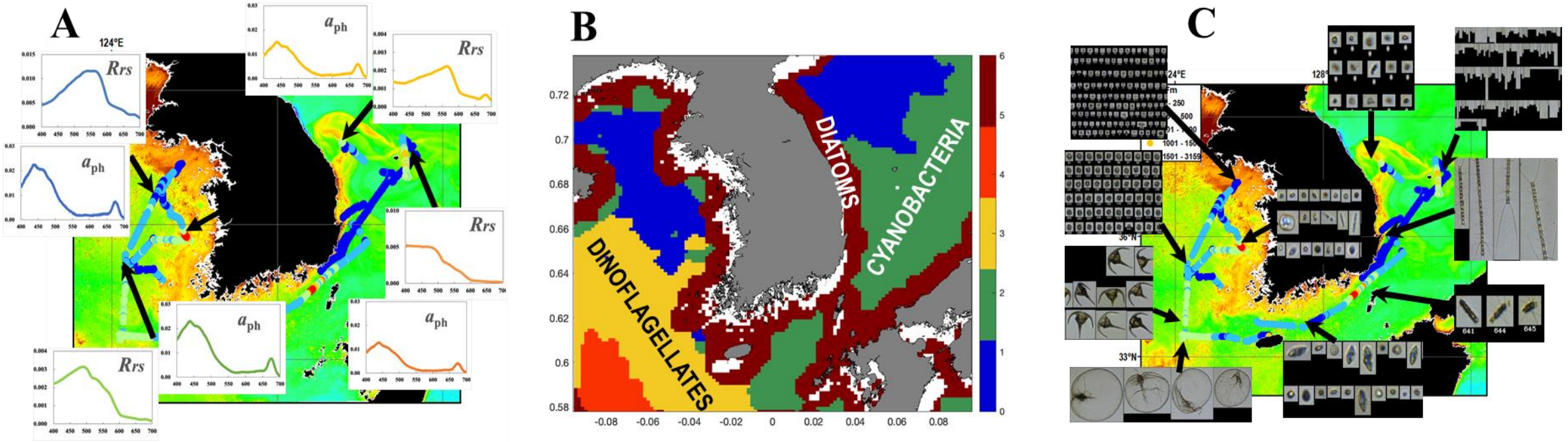


Figure. (A) differences in in-situ $R_{rs}(\lambda)$ and $a_{ph}(\lambda)$ obtained during the NASA KORUS cruise (May-June 2016). (B) OWTs generated using GOCI, plus hydrographic and bathymetry data. (C) Phytoplankton functional types obtained with the help of a FlowCAM operated using a continuous flow-through system developed by co-I Goes.

Case 2: Application to AVIRIS-NG and PRISM overflights

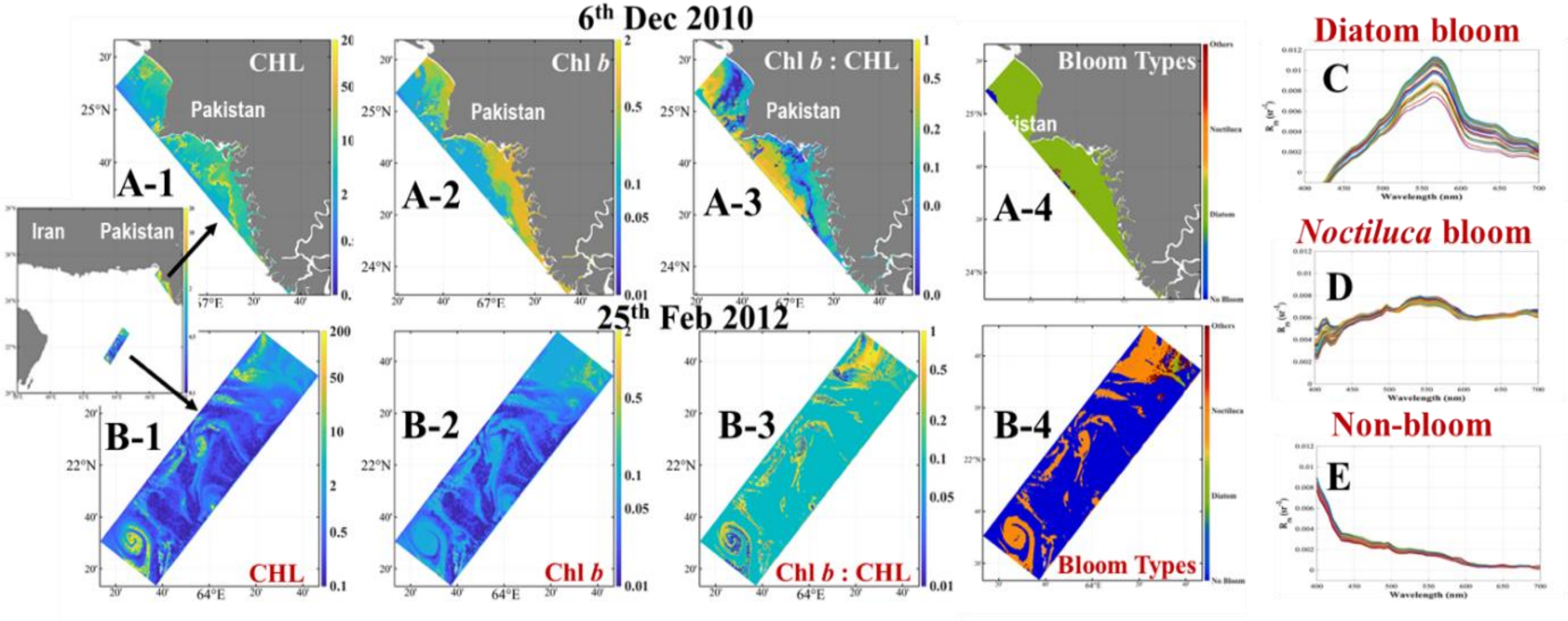


Figure. CHL and Chl *b*, Chl *b*:CHL *a* ratios and bloom types derived from two HICO scenes in the AS, the upper panels for 6th Dec. 2010 obtained along the coast of Pakistan (A1-A4) and for 25th Feb 2012 in the central AS (B1-B5). The major PFTs derived along the coast of Pakistan were diatoms but in the Central AS, the high CHL a patches were primarily *Noctiluca*. The PFTs for the Central Arabian Sea reval the presence of diatoms and other PFTs and the patterns are consistent with shipboard data. The distinct *Rrs* (l) spectra for Diatom and *Noctiluca* bloom rich and non-bloom waters are visible at the right (C-E).